

and shows approximately the southern limit of frost on exposed surfaces.

### WIND.

The *prevailing winds* for April, 1896, viz, those that were recorded most frequently, are shown in Table I for the regular Weather Bureau stations.

The *resultant winds*, as deduced from the personal observations made at 8 a. m. and 8 p. m., are given in Table IX. These latter resultants are also shown graphically on Chart IV, where the small figure attached to each arrow shows the number of hours that this resultant prevailed, on the assumption that each of the morning and evening observations represents one hour's duration of a uniform wind of average velocity. These figures indicate the relative extent to which winds from different directions counterbalanced each other.

### HIGH WINDS.

*Maximum wind velocities* of 50 miles or more per hour were reported at regular stations of the Weather Bureau as follows (maximum velocities are averages for five minutes; extreme velocities are gusts of shorter duration, and are not given in this table):

Stations.	Date.	Velocity.	Direction.	Stations.	Date.	Velocity.	Direction.
		<i>Miles</i>				<i>Miles</i>	
Abilene, Tex.....	12	60	sw.	El Paso, Tex.....	12	64	sw.
Amarillo, Tex.....	10	60	s.	Do.....	27	50	sw.
Do.....	11	54	s.	Fort Canby, Wash.....	6	54	s.
Do.....	28	66	w.	Do.....	24	58	s.
Buffalo, N. Y.....	2	54	w.	Do.....	30	60	s.
Chicago, Ill.....	10	57	se	Huron, S. Dak.....	7	51	se.
Do.....	13	59	s.	Do.....	25	50	s.
Do.....	18	60	s.	Moorhead, Minn.....	28	51	se.
Cleveland, Ohio.....	2	56	w.	New York, N. Y.....	4	52	nw.
Do.....	3	54	w.	Pueblo, Colo.....	12	54	n.
Denver, Colo.....	30	50	nw.	Rapid City, S. D.....	28	58	n.
Dodge City, Kan.....	12	55	s.	Santa Fe, N. Mex.....	10	50	sw.
Do.....	17	54	s.	Sioux City, Iowa.....	26	50	nw.
Do.....	28	50	s.	Williston, N. Dak.....	19	52	w.
Duluth, Minn.....	1	52	nw.				

### HAIL.

The following are the dates on which hail fell in the respective States:

Alabama, 21, 26, 29. Arizona, 11, 17, 27. Arkansas, 7, 21, 22, 25, 26, 28, 29. California, 6, 9, 10, 13 to 16, 18, 19, 22, 24 to 30. Colorado, 17, 28, 30. Connecticut, 25. Florida, 25. Georgia, 24, 25, 27. Idaho, 6, 7, 8, 10, 12 to 16, 18, 19, 20, 22, 25, 27 to 30. Illinois, 7, 10, 13, 18, 20, 21, 23, 26, 28, 29. Indiana, 8, 20, 21, 24, 27. Iowa, 7, 9 to 13, 19, 20, 23, 25, 26, 28, 29. Kansas, 5 to 8, 10 to 13, 16 to 22, 24, 25, 26, 28, 30. Kentucky, 21, 23, 24, 26, 29. Louisiana, 13, 14. Maryland, 11. Massachusetts, 17, 19, 20. Michigan, 11, 17. Minnesota, 1, 11, 13, 16, 17, 23, 25 to 29. Mississippi, 26, 27, 29. Missouri, 7, 8, 9, 13, 17, 20, 21, 22, 24 to 30. Montana, 13. Nebraska, 5, 7 to 12, 16, 17, 20, 23, 25, 26, 28, 30. Nevada, 6, 15, 16, 17, 19 to 22, 25, 26, 28, 29. New Jersey, 2, 21. New York, 2, 4, 6, 17, 20, 21, 25. North Carolina, 8, 9, 17, 24, 25. North Dakota, 8, 11, 12, 26, 27. Ohio, 1, 11, 20, 21, 24, 27 to 30. Oklahoma, 8. Oregon, 5 to 10, 14, 15, 17, 18, 24, 25, 27 to 30. Pennsylvania, 17, 21. South Carolina, 24, 25. South Dakota, 11, 17, 23, 25, 27. Tennessee, 20, 21, 22, 24, 26, 27, 30. Texas, 1, 2, 3, 8, 11, 12, 13, 21, 22, 28, 30. Utah, 10, 11, 14, 20. Virginia, 9, 17, 24. Washington, 2, 6, 7, 8, 10 to 15, 18, 21, 25, 28, 29. West Virginia, 21, 24, 29, 30. Wisconsin, 1, 10, 11, 13, 16, 17, 18, 20, 27, 28.

### SLEET.

The following are the dates on which sleet fell in the respective States:

Arizona, 11, 27. California, 9, 11, 14, 15, 16. Colorado, 10 to 13, 16, 17, 26. Connecticut, 2. Idaho, 10, 11, 18. Illinois,

6 to 9. Indiana, 8. Iowa, 7, 8, 9. Kentucky, 8. Maine, 2, 7, 22. Maryland, 6, 9. Massachusetts, 2, 22. Michigan, 1, 9, 10, 22. Minnesota, 6, 7, 8, 11, 16, 17. Missouri, 8, 13. Montana, 30. Nebraska, 11, 12, 17. Nevada, 9, 10, 13, 15, 16, 17, 19, 22, 26, 27. New Hampshire, 2. New Jersey, 2, 7, 10. New York, 2. North Carolina, 9. North Dakota, 1, 7, 8, 11, 12, 13, 15, 16, 17. Ohio, 1, 8, 9. Oregon, 9, 12, 18, 24, 29, 30. Pennsylvania, 2 to 9. South Dakota, 6, 7, 10, 11, 17. Texas, 2, 3, 17. Utah, 14, 16, 17. Virginia, 9. Washington, 1, 2, 25. West Virginia, 9. Wisconsin, 1, 2, 7, 9.

### SUNSHINE AND CLOUDINESS.

The quantity of sunshine, and therefore of heat, received by the atmosphere as a whole is very nearly constant from year to year, but the proportion received by the surface of the earth depends upon the absorption by the atmosphere, and varies largely with the distribution of cloudiness. The sunshine is now recorded automatically at 17 regular stations of the Weather Bureau by its photographic, and at 21 by its thermal effects. At one station records are kept by both methods. The photographic record sheets show the apparent solar time, but the thermometric sheets show seventy-fifth meridian time; for convenience the results are all given in Table XI for each hour of local mean time.

Photographic and thermometric registers give the duration of that intensity of sunshine which suffices to make a record, and, therefore, they generally fail to record for a short time after sunrise and before sunset, because, even in a cloudless sky, the solar rays are then too feeble to affect the self-registers. If, therefore, such records are to be used for determining the amount of cloudiness, they must be supplemented by special observations of the sky near the sun at these times. The duration of clear sky thus specially determined constitutes the so-called twilight correction (more properly a low-sun correction), and when this has been applied, as has been done in preparing Table XI, there results a complete record of the clearness of the sky from sunrise to sunset in the neighborhood of the sun. The twilight correction is not needed when the self-registers are used for ascertaining the duration of a special intensity of sunshine, but is necessary when the duration of cloudiness is alone desired, as is usually the case.

The average cloudiness of the whole sky is determined by numerous personal observations at all stations during the daytime, and is given in the column "average cloudiness" in Table I; its complement, or percentage of clear sky, is given in the last column of Table XI.

### COMPARISON OF DURATIONS AND AREAS.

The sunshine registers give the *durations* of effective sunshine whence the duration relative to possible sunshine is derived; the observer's personal estimates give the percentage of *area* of clear sky. These numbers have no necessary relation to each other, since stationary banks of clouds may obscure the sun without covering the sky, but when all clouds have a steady motion past the sun and are uniformly scattered over the sky, the percentages of duration and of area agree closely. For the sake of comparison, these percentages have been brought together, side by side, in the following table, from which it appears that, in general, the instrumental records of percentages of durations of sunshine are almost always larger than the observers' personal estimates of percentages of area of clear sky; the average excess for April, 1896, is 5 per cent for photographic and 14 per cent for thermometric records. The details are shown in the following table, in which the stations are arranged according to the greatest possible duration of sunshine, and not according to the *observed* duration as heretofore.

## Difference between instrumental and personal observations of sunshine.

Stations.	Apparatus.	Total possible duration for the whole month.	Personal estimated area of clear sky.	Instrumental record of sunshine.			
				Photographic.	Difference.	Thermometric.	Difference.
Bismarck, N. Dak.	P.	408.4	38	42	+4		
Helena, Mont.	P.	408.4	52	54	+2		
Portland, Oreg.*	P.	407.0	37	30	-7	30	-
Eastport, Me.	T.	405.2	44	54	+10		
Northfield, Vt.	P.	403.6	45	54	+9		
Portland, Me.	T.	403.6	40			59	+19
Rochester, N. Y.	T.	402.1	55			68	+13
Buffalo, N. Y.†	T.	402.1	37			51	+14
Boston, Mass.	T.	401.1	53			61	+7
Chicago, Ill.	P.	401.1	54	57	+14	63	+9
Cleveland, Ohio.	T.	401.1	43				
Des Moines, Iowa.	T.	401.1	39			65	+26
Detroit, Mich.	P.	401.1	52	38	+4	62	+10
Eureka, Cal.	T.	399.4	34				
New York, N. Y.	P.	399.4	49	56	+28	57	+8
Salt Lake City, Utah.	T.	399.4	28				
Colorado Springs, Colo.	P.	398.6	45	76	+20	62	+17
Denver, Colo.	T.	398.6	56				
Philadelphia, Pa.	T.	398.6	47			71	+24
Baltimore, Md.	T.	397.0	46			47	+1
Cincinnati, Ohio.	P.	397.0	56	50	+5	79	+23
Kansas City, Mo.	T.	397.0	45				
St. Louis, Mo.	P.	397.0	53	55	-4	72	+19
Washington, D. C.	P.	397.0	59	68	+8		
Dodge City, Kans.	T.	396.2	60				
Louisville, Ky.	T.	396.2	55			81	+26
San Francisco, Cal.	P.	396.2	44	84	+16	62	+18
Santa Fe, N. Mex.	T.	393.6	68				
Little Rock, Ark.	T.	392.7	37			73	+36
Atlanta, Ga.	T.	391.6	59			79	+20
Wilmington, N. C.	P.	391.6	69	84	+6	83	+14
San Diego, Cal.	P.	390.5	78	91	+11		
Phoenix, Ariz.	P.	390.5	80	72	+13		
Savannah, Ga.	T.	389.9	59				
Vicksburg, Miss.	T.	389.9	67			67	0
New Orleans, La.	P.	387.4	48	44	+9	50	+2
Galveston, Tex.	T.	386.4	35				

\* Records by both methods. † Records for only 21 days, for which the total possible duration of sunshine was 285.9 hours.

## ATMOSPHERIC ELECTRICITY.

Numerical statistics relative to auroras and thunderstorms are given in Table X, which shows the number of stations from which meteorological reports were received, and the number of such stations reporting thunderstorms (T) and auroras (A) in each State and on each day of the month, respectively.

The dates on which reports of thunderstorms for the whole country were most numerous were: 17th, 269; 20th, 204; 24th, 186; 28th, 196; 29th, 216.

Thunderstorm reports were most numerous in Illinois, 178; Iowa, 218; Minnesota, 204; Missouri, 249; Ohio, 279; Wisconsin, 180.

Thunderstorms were most frequent in: Iowa, Missouri, Nebraska, Wisconsin, 23 days; Michigan, 22; Minnesota, 20.

Auroras.—The evenings on which bright moonlight must have interfered with observations of faint auroras are assumed to be the four preceding and following the date of full

moon, viz, the 1st, and also from the 21st to the 30th, inclusive. On the remaining twenty days of this month 138 reports were received, or an average of about 7 per day. The dates on which the number of reports especially exceeded this average were: 3d, 57; 4th, 44; 21st, 39.

Auroras were reported by a large percentage of observers in: North Dakota, 89; Wisconsin, 57; Michigan, 38; Minnesota, 43.

Auroras were reported most frequently in: North Dakota, 13 days; Michigan, 11; Wisconsin, 7; Minnesota, 6.

## CANADIAN REPORTS.

Thunderstorms were reported as follows: 7th, Qu'Appelle; 11th, Port Stanley, Winnipeg; 12th, Saugeen; 17th, Toronto, White River, Port Stanley, Parry Sound; 18th, Port Arthur, Charlottetown; 20th, Port Stanley; 22d, Qu'Appelle; 25th, Swift Current; 27th, Qu'Appelle, Medicine Hat; 30th, Port Stanley.

Auroras were reported as follows: 2d, Prince Albert; 3d, Rockliffe, Port Arthur, Medicine Hat, Prince Albert; 4th, Rockliffe, Toronto, Medicine Hat; 5th, Father Point, Port Arthur, Winnipeg, Minnedosa, Battleford; 7th, Port Arthur; 8th, Father Point, Toronto; 9th, Father Point; 10th, Battleford; 11th, Quebec, Battleford; 12th, Battleford; 17th, Battleford; 20th, Quebec; 21st, Charlottetown, Father Point, Toronto, Minnedosa, Medicine Hat, Battleford; 22d, Charlottetown, Quebec, Toronto, Port Arthur; 23d, Father Point; 24th, Quebec; 26th, Port Arthur; 28th, Quebec; 30th, Battleford.

## INLAND NAVIGATION.

The extreme and average stages of water in the rivers during the current month are given in Table VIII, from which it appears that a number of rivers attained the danger line, although the flood stages were of comparatively short duration. The Tennessee reached its highest point at Chattanooga on the 5th and at Johnsonville on the 12th; the Cumberland was highest at Burnside on the 2d and at Nashville on the 7th; the Ohio was highest at Cincinnati on the 4th. As a result of these and other high waters, the Mississippi was highest at Helena on the 17th and at New Orleans on the 23d.

## METEOROLOGY AND MAGNETISM.

By Prof. FRANK H. BIGELOW.

For a description of the methods of constructing the tables and curves of Chart V, see the WEATHER REVIEW for October, 1895, and January, 1896. The numbers in the columns H. and D. are added respectively to the mean values for Washington and Toronto, i. e.,  $H=0.18250$ ;  $D=180.0$ . The values of the vertical forces are omitted, as well as  $dz$ ,  $s$  and  $\alpha$ , which depend upon it. Stagnant eastward circulation continued during April, and summer continental conditions, with high areas on the coast and a low area in the central valleys prevailed. From the 11th to the 14th the Atlantic high was abnormally warm, causing an excess over the seasonal temperature. The solar magnetic type was inverse during the month.

## CLIMATE AND CROP SERVICE.

By JAMES BERRY, Chief of Climate and Crop Service Division.

The following extracts relating to the general weather conditions in the several States and Territories are taken from the monthly reports of the respective services.

Snowfall and rainfall are expressed in inches.

Alabama.—The mean temperature was 68.3°, or 4.8° above normal; the highest was 94°, at Tuscaloosa on the 23d and 26th, and at Pineapple on the 24th, and the lowest, 30°, at Healing Springs, Pineapple, and Valleyhead on 3d. The average precipitation was 3.75, or 1.37 below normal; the greatest monthly amount, 11.30, occurred at Pushmataha

(of which amount 7.40 fell on the night of the 13th), and the least, 1.24 at Sturdevant.

Arizona.—The mean temperature was 60.3°, or 0.7° above normal; the highest was 97°, at Maricopa on the 27th, and the lowest, 8°, at Flagstaff on the 18th. The average precipitation was 0.21, or 0.27 less than normal; the greatest monthly amount was 3.00, at Pantano; no precipitation occurred at several stations.

Arkansas.—The mean temperature was 65.2°, or 2.4° above normal; the highest was 94°, at Warren on the 26th, and the lowest, 24°, at Keesees Ferry on the 2d and 3d. The average precipitation was 3.65,